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EX PARTE OR LATE FILED

October 12, 1999

RECEIVED

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
Washington, D.C. 20554

Re: RM-9375 – *Ex Parte* Notice

Dear Ms. Salas:

This is to note that on October 8, 1999, Joesef Schuermann, a consultant to Texas Instruments, and I met with Mr. Fred Thomas of the Commission's Office of Engineering and Technology, and with Messrs. Norbert Schroeder and Robert Haines of the National Telecommunications and Information Administration to discuss the petition for rule making referred to above. We provided an oral briefing on how radio frequency identification systems at 13.56 MHz operate and discussed the possibility of an amended request for rule making that would have the revised emissions mask return to the current general limits at 13.56 MHz +/- 450 kHz instead of the mask proposed in the petition. We also discussed the test that was conducted last year at the radio observatory near Nancay, France, in which RF identification equipment was operated at 13.56 MHz to evaluate the potential for interference to the radio observatory. A copy of the report of this test along and a collection of information pertaining to radio astronomy in the high frequency portion of the spectrum were provided and are enclosed herewith. We also noted that we had met with Federal Aviation Administration frequency management personnel to discuss the proposal.

Respectfully,

David E. Hilliard

David E. Hilliard
Counsel for Texas Instruments, Inc.

Enclosure: Nancay Report and Radio Astronomy Notes
cc: Messrs. Thomas, Schroeder, and Haines

No. of Copies rec'd 0+1
List ABCDE

To : PTSE 24
Re: Astronomy INFO for interferenc assessment/13.56 MHz band /EN 300 330
Fr: J. Schuermann

RESEARCH: RE RADIO ASTRONOMY IN THE 13.36 - 13.41 MHZ BAND

Observing the Jovian Decametric Emission. [http://www.astro.ufl.edu/radio/listen.txt]

There have been reports of detection of the Jovian decametric emission with simple half wavelength dipole antennas or low gain antennas such as the long-wire type or loop antennas. Such low gain antennas may allow the detection of only very strong bursts.
Antennas with gains of 6-10 dB with respect to a half wavelength dipole are more suitable for detecting the emission. Yagi (5- elements) and log periodic antennas usually have gains in this range. These higher gain antennas connected to HF amateur radio receivers can easily detect most of the strong part of the Jovian decametric radio emission. It will be necessary for good reception of Jupiter that the antenna points towards the planet. This may be difficult since most amateur antennas only have azimuthal control. Most amateur HF radio receivers are suitable for detecting the emission since they have a relatively narrow passband and adequate noise figure. The relative narrow band of these receivers will help in tuning away from radio stations. It will be necessary to disable the AGC of the receiver otherwise the signal will be badly compressed. An observing frequency between 18-22 MHz is recommended. At frequencies below 18 MHz strong interference from stations and static is expected. At frequencies higher than 22 MHz, the probabilities of detecting the emission drop sharply because of the drop in intensity of the emission (see attached histogram of occurrence probability). Although the low solar activity expected for this year is a favorable condition for detecting the emission during the period of the collision, the low value of DE (around -3.4 degrees for July, 1994) reduces the probabilities of detection. _
As a reference, the minimum detectable flux density (power per unit area per unit bandwidth) expected for an 8 dB gain linearly polarized antenna connected to a receiver having a 5 kHz bandwidth and an output time constant of 1 second is of the order of 5X10^-22 wm^-2Hz^-1 at a frequency of 18 MHz. Jovian decametric radio emission with peak flux densities in the range of **10- 100X10^-22 wm^-2Hz^-1** are common.
Expressing the flux density in Jansky (Jy), a unit more commonly used in radio astronomy, these peak flux densities are 100,000 to 1,000,000 Jy (1 Jy= 1X10^-26 wm^-2Hz^-1).
In10x10^-22 wm^-2Hz^-1 is equivalent to a power of 1x10-9 terms of power and voltage at the input of a receiver, microwatt or 0.23 microvolt over 50 Ohms.
A few more additions need to be considered if the information gathered is to used for scientific purposes. A source of calibrated noise is necessary in order to calibrate the intensity of the signal. As an example, an HP 461A amplifier can be used as a noise source (with a variable attenuator), but the noise temperature of the amplifier must be calibrated against a standard noise source such as the type 5722 current-saturated noise diodes.
Timing information is also an important consideration. WWV timing signals can provide adequate timing information. The ability to identify the Jovian emission and separate it from stations, static, or other types of interference is also important. Recording of the receiver output in paper chart records provide a nice way of monitoring the emission. The chart records can be used for further data reduction and analysis, but their use is sometimes time consuming. A personal computer with an A/D converter will provide a better way to store, retrieve, and process the information (if further data reduction and analysis are to be made). Time constants of about 1 second are adequate for recording the envelope of the emission. Shorter time constants (10-20 milliseconds or shorter) are necessary to resolve the faster S bursts.

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01/97

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Planetary Radio Astronomy [http://www.astro.ufl.edu/urania/urania-fall94.html]

The planetary radio astronomy group is involved in many aspects of the study of radio emissions from the giant planets. Our data set includes that taken by the Planetary Radio experiment on board the Voyager spacecraft, as well as over 30 years of data taken at the University of Florida Radio Observatory (UFRO). Our group operates the UFRO, one of the two largest observatories in the world dedicated to the study of decametric radio emission from the planet Jupiter. Currently Drs. Carr and Reyes are studying very-fine structure in the dynamic spectra of the Jovian decametric emission. We are also interpreting the longer time-scale morphology of the decametric emission and how it relates to emission locations and mechanisms within the Jovian magnetosphere. Along with Kazumasa Imai, a visiting scientist from Japan, we are developing models explaining certain types of lane features present in the decametric radiation from Jupiter. Chuck Higgins is using data taken over a period of several years at the UFRO to determine a more precise value of the Jovian rotation period. He is also studying the hectometric radio data taken by the Voyager spacecraft during its encounter with Jupiter. Leonard Garcia is using UFRO radio data to determine the shape of the emission beams from Jupiter and the influence that changes in aspect have on Jovian decametric radio emissions.

Our group played a leading role in the search for decametric radio emissions due to the impact of comet Shoemaker-Levy 9 (SL9). Francisco Reyes and Jorge Levy traveled to Maipu Radio Astronomy Observatory (MRAO) near Santiago, Chile to help upgrade the observatory. Wes Greenman, Leonard Garcia and Dr. Carr traveled to Owens Valley Radio Observatory (OVRO) to help construct a temporary decametric station and to man the station for a month before and during the impact. Francisco Reyes also served as the head of the International Jupiter Watch decametric network. He organized the observations of over a dozen radio astronomers from around the world for this once-in-a-lifetime event. Our group staffed the UFRO for months before the event and kept the observatory running for about 10 hours each night during impact week despite the ever-present thunderstorms of a Florida summer. Preliminary results of our observations were shown at the Symposium on Magnetospheres of the Outer Planets in Graz, Austria this past August. The combined observations from UFRO, MRAO and OVRO will be published in a special SL9 issue of Earth, Moon and Planets. Our group is still very much involved in studying the data taken during the impact and more results will be published soon. /Garcia

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The Jovian Decametric Emission. [http://www.astro.ufl.edu/radio/dam.txt

The Jovian decametric emission was discovered in 1955 by B.F. Burke and K.L. Franklin at the frequency of 22.2 MHz. The emission has an upper cutoff frequency of 39.5 MHz. It can be detected from ground based stations from the upper cutoff frequency of the emission down to the cutoff frequency of the terrestrial ionosphere which is usually around 5 to 10 MHz. The peak of the intensity of the emission occurs at around 8 MHz. The emission occur in episodes called "storms". A storm can last from a few minutes to several hours. Two distinctive types of bursts can be received during a storm. The L bursts (L for Long) are bursts that vary slowly in intensity with time. They last from a few seconds to several tens of seconds and have instantaneous bandwidth of a few MHz. The S bursts (S for Short) are very short in duration, have instantaneous bandwidth of a few kHz to a few tens of kHz, and drift downward in frequency at a rate of ypically -20 MHz/sec. They arrive at a rate of a few to several hundred bursts per second. In a 5 kHz bandwidth receiver they last only a few milliseconds. Sometimes both types of bursts can be heard simultaneously. The emission is believed to be beamed into a thin hollow cone with axis parallel to the direction of the magnetic field lines in the region where the emission originates (near the magnetic poles). The probabilities of detecting the emission depend strongly on the values of the Jovian central meridian longitude (CML), the Io Phase, and the Jovicentric declination of the Earth (DE). The CML is the value of the System III longitude of Jupiter facing the Earth. The Io Phase is the angle of Io, one of Jupiter's moons, with respect to superior geocentric conjunction. The regions in the CML-Io phase plane that have increased probabilities of emission are called sources. The sources are named Io-A, Io-B, and Io-C for the Io- controlled emission and A, B, and C for the Non-Io controlled emission.

Source CML Io Phase Characteristics of emission Io-related sources
Io-A 200-290 195-265 RH polarized, mostly L bursts Io-B 90-200 75-105 RH polarized, mostly S bursts
Io-C 290-10 225-250 LH polarized, L and S bursts Non-Io related sources, A 200-290, B 90-200, C 290-10

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http://www.astro.ufl.edu/grad-stu.html
UF's role in Observing Shoemaker-Levy 1993e/Jupiter encounter, [http://www.astro.ufl.edu/urania/urania-spring94.html

In July of this year an extraordinarily rare astronomical event will be taking place on the planet Jupiter. Shoemaker-Levy 1993e, a stream of approximately two dozen comet-like fragments with an average size of about 2 km will be colliding with Jupiter. Though events of this kind must have occurred countless times in Jupiter's history, this will be the first time mankind will directly witness such an event. The geometry of the encounter for earthbound observers will, however, be less than ideal. It is expected that the fragments will actually strike Jupiter just past the limb of the planet as seen from Earth. This has not stopped astronomers from making plans to observe this impact, and in fact at this time vigorous planning is taking place around the world to prepare for this event. The University of Florida will also be contributing to this massive observational effort. Both the UF Radio Observatory and Rosemary Hill Observatory are upgrading their equipment to take advantage of this rare opportunity. The cometary studies group will also be involved in making detailed observations of the impact from telescopes in the Canary Islands.
The planetary radio group will be investigating the effects that Shoemaker-Levy 1993e has on the magnetosphere of Jupiter by observing the decametric radio emission from Jupiter before, during and after the encounter. Dr. Carr, director of the UF Radio Observatory (UFRO), has received a grant from NASA to expand observations during the collision to three other sites. The three sites will be located at Owens Valley, California (in collaboration with Tony Phillips of CalTech), Maipu Radio Observatory (Chile) and Hawaii. Together these stations will be able to observe Jupiter for nearly 12 hours. Francisco Reyes is directing the efforts of more than a dozen decametric radio observers around the world through the International Jupiter Watch Decametric Network. The network will allow close contact among the radio observatories during the collision and alert the observatories of any unusual changes in the emission. The combined observations will provide nearly 24 hours of coverage in the low frequency radio. The planetary radio group has also made its Jupiter ephemeris tables for the months prior and during the encounter available to the astronomical community by placing them on the UF astronomy ftp site astro.ufl.edu under the pub/jupiter directory.
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UF Radio Observatory [http://www.astro.ufl.edu/ufro/dam.txt

The UFRO has upgraded its facilities to improve its monitoring of Jovian decametric emission. The observatory now has sixteen log spiral antennas for monitoring both left and right hand polarization over frequencies from 18 to 32 MHz. This upgrade will allow researchers to better characterize the radiation coming from Jupiter. The UFRO was active in observing Jupiter decametric emissions during the collision of comet Shoemaker-Levy 1993e with Jupiter in late July, 1994. A new computer-controlled receiver was purchased allowing *the frequency to be switched in 500 kHz steps from 18 to 30 MHz.* Data during the encounter was taken from the receiver in a variety of different formats. Besides the paper chart records which are useful for recording observer notes and the PC-digitized data at 2 samples per second another computer was sampling the output at 100 samples per second during the time of each comet fragment impact. High speed wide band data recording was performed for even higher frequency and time resolution. Our work resulted in two papers Search for Effects of Comet S-L 9 Fragment Impacts on Low Radio Frequency Emission From Jupiter as well as Results of Decametric Monitoring of the Comet Collision with Jupiter.

Francisco Reyes has provided information on: Jupiter's Decametric Radio Emission and on How to Observe Jupiter Radio Emissions Jupiter Prediction Tables

The University of Florida Radio Observatory (UFRO) has generated a listing of the prediction of the configurations of CML, Io Phase, the active sources, and the probabilities of emission at 18.0 and 26.3 MHz. The probabilities at 26.3 MHz are valid for an antenna of large collecting area (These probabilities were obtained with the 640 dipoles of the UFRO 26.3 MHz Large Array), and are included as reference only. If these tables prove useful in your research please acknowledge us in your paper. We also have a description of these tables.

SOUNDS OF JUPITER

These UNIX .au files are narrated by Dick Flagg and contain sounds recorded at the University of Florida Radio Observatory.
The first sound file gives a brief description of two types of Jovian emission, the L-bursts and the S-bursts. The Galactic background radiation (refered to in the sound file as cosmic radio noise) is briefly described and a sample of the noise is given. L-bursts can be heard in the third sound file as waves of higher amplitude emission over the ever present galactic background. The S-bursts recorded in the fourth sound file are the short snapping or popping sounds but when recorded at high speed and slowed down by a factor of 128 to 1, the S-bursts in the fifth file can be heard to sweep downward in frequency.

<Picture>A brief introduction (308183 bytes)
<Picture>L-Bursts (415045 bytes)
<Picture>S-Burst 128:1 slowdown (725450 bytes)
<Picture>The Galactic Background Radiation (255195 bytes)
<Picture>S-Bursts (312469 bytes)
[garcia@astro.ufl.edu
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The Committee on Radio Astronomy Frequencies (CRAF) is a committee of the European Science Foundation (ESF).
Frequency band allocated to the Radio Astronomy Service: [http://www.nfra.nl/craf/38m.htm#5

ITU-R allocations (+ footnotes):

30.01 - 37.5 MHz:	37.5 - 38.25 MHz:	38.25-39.986 MHz:
FIXED MOBILE	FIXED MOBILE Radio Astron.	FIXED MOBILE

Astrophysical importance of the band 37.5 - 38.25 MHz

The band 37.5 - 38.25 MHz has worldwide a secondary allocation (see FN S5.149). Together with the bands 13.36 - 13.41 MHz and 25.55 - 25.67 MHz this band is very important for research of radiation from Jupiter. Long after all the decametric frequency bands have been allocated and widely used by active services Jovian decametric radiation was discovered. The allocations to the Radio Astronomy Service are extremely narrow since the interesting Jovian phenomena can cover the entire spectrum from 3 - 40 MHz. Jupiter is the only radio-planet observable from the ground and its study is a unique mean of developping theoretical models for the radio emissions of all the other planets.

These three bands (13.36 - 13.41 MHz, 25.55 - 25.67 MHz and 37.5 - 38.25 MHz) are also used for solar observations. Also for this research the allocations are extremely narrow, since the interesting solar phenomena can cover the entire spectrum up to 70 MHz. The Sun is the nearest star and its study enables a closer understanding of the radio emission mechanisms of all other stars.

The allocation of the band 37.5 - 38.25 MHz was modified only slightly by WARC 79.
On a worldwide basis the Radio Astronomy Service has a secondary allocation shared with the Fixed and Mobile Services. Despite the secondary allocation, this band is often free of interference and is quite useful for radio astronomy.

Threshold levels of interference detrimental to radio astronomy continuum observations:
System Sensitivity (noise fluctuations)Threshold Interference LevelsTemperaturePower Spectral DensityInput PowerPower Flux DensitySpectral Power Flux DensitySingle Dish250 mK-235 dB(WHz-1)-180 dBW-198 dB(Wm-2)-251 dB(Wm-2Hz-1)

In Europe, the band 37.5 - 38.25 MHz is used by the Radio Astronomy Service in: •France •United Kingdom

Threats to the Radio Astronomy Service:
Sharing problems with the following services: •Fixed Service •Mobile Service
Out-of-band emission from the following services: •Fixed Service •Mobile Service

Last modified: February 18, 1998

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Status of interference problems in France: [http://www.nfra.nl/craf/fra.htm#1m
•Bordeaux •Nançay •Plateau de Bure (operated by the Institut de Radioastronomie Millimétrique, IRAM)

• 13.36 - 13.41 MHz
This band is used by the Nançay Radio Observatory:

Radio astronomical quality of the band:
• reasonable: often severe degradation by harmful interference.

Reason:
• Aeronautical Mobile Service applications.
• Fixed Service applications.

• 25.55 - 25.67 MHz
This band is used by the Nançay Radio Observatory:

Radio astronomical quality of the band:
• reasonable: often severe degradation by harmful interference.

Reason:
• Broadcasting Service applications.
• Fixed Service applications.
• Mobile Service applications.

• 37.5 - 38.25 MHz
This band is used by the Nançay Radio Observatory:

Radio astronomical quality of the band:
• reasonable: often severe degradation by harmful interference.

Reason:
• Fixed Service applications.
• Mobile Service applications.
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Committee on Radio Astronomy Frequencies [http://www.nfra.nl/craf/harmdef.htm

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Harmful Interference:
Harmful Interference can be caused in the case of Frequency Sharing, by Out-of-band Emission and by Spurious Emission.
Concering Interference and Harmful Interference the ITU-R Radio Regulations use the following definitions:

Interference: The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, or loss of information which could be extracted in the absence of such unwanted energy.

Harmful Interference: Interference which endangers the functioning of a Radionavigation Service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with the ITU-R Radio Regulations.

Harmful Interference to the Radio Astronomy Service:
Interference levels are considered to be harmful to the Radio Astronomy Service when the rms fluctuations of the system noise increase at the receiver output by 10% due to the presence of interference.

ITU-R RA.769-1 gives the levels of harmful interference for the Radio Astronomy Service based on this criterion and the adopted integration time of 2000 seconds. It should be noted that in practice it depends completely on the type of telescope and the operating parameters used whether interference is considered harmful. For example: the conditions are different for single dish observations, radio interferometry and Very Long Baseline Interferometry (VLBI); or whether observations are done of spectral lines or in a broadband continuum mode. Usualy each instruments has a number of different operating parameters. The values given in ITU-R RA.769-1 general "averages" and give an indication of the levels at which an interfering signal degrades the observations significantly.

Percentage of time lost by the Radio Astronomy Service due to harmful interference:
In cases where the strength of an interfering signal varies as a result of time-varying propagation conditions, for example in the case of propagation by tropospheric scatter, the usual practice in interference calculations for radio astronomy is to consider the level for which the propagation loss is exceeded for 90% of time. Thus the harmful threshold would be exceeded for 10% of time, and in removing contaminated data 10% of the observations would be lost. Radio astronomers generally agree that this is the maximum tolerable loss. In general this figure applies to interference which intermittently exceeds the harmful threshold for time periods such that no more than 10% of the data is contaminated. In terms of the time averaging no more than 10% of the initially-averaged data (for example of tens of milliseconds to tens of seconds) should be lost when contaminated data is rejected. Thus, for example, interference from a radar signal, the mean power of which exceeds the harmful threshold, would not be tolerable even if the duty cycle of the transmitter is less than 10% (ITU-R Handbook on Radio Astronomy).
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Committee on Radio Astronomy Frequencies

Frequency Sharing: [http://www.nfra.nl/craf/shardef.htm
Frequency Sharing occurs when a frequency band is allocated to more than one radiocommunication service. This condition implies a potential threat of harmful interference.

Concering Frequency Sharing the ITU-R Radio Regulations use the following definitions:

Interference: The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, or loss of information which could be extracted in the absence of such unwanted energy.

Permissible Interference: Observed or predicted interference which complies with quantitative interference and sharing criteria contained in the ITU-R Radio Regulations or in CCIR Recommendations or in special agreements as provided for in the ITU-R Radio Regulations. The term "permissible interference" is used in the coordination of frequency assignments between administrations.

Acceptable Interference: Interference at a higher level than that defined as permissible interference and which has been agreed upon between two or more administrations without prejudice to other administrations. The term "permissible interference" is used in the coordination of frequency assignments between administrations.

Harmful Interference: Interference which endangers the functioning of a Radionavigation Service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with the ITU-R Radio Regulations.

Protection Ratio (R.F.): The minimum value of the wanted-to-unwanted signal raatio, usually expressed in decibels, at the receiver input, determined under specified conditions such that a specified reception quality of the unwanted signal is achieved at the receiver input.

Coordination Area: The area associated with an earth station outside of which a terrestrial station sharing the same frequency band neither causes nor is subject to interfering emissions greater than a permissible level.

Coordination Contour: The line enclosing the coordination area.

Coordination Distance: Distance on a given azimuth from an earth station beyond which a terrestrial station sharing the same frequency band neither causes nor is subject to interfering emissions greater than a permissible level.

Equivalent Satellite Link Noise Temperature: the noise temperature referred to the input of the receiving antenna of the earth station corresponding to the radio frequency noise power which produces the total observed noise at the output of the satellite links using other satellites and from terrestrial systems.

Effective Boresight Area (of a steerable satellite beam): An area on the surface of the Earth within which the boresight of a steerable satellite beam is intended to be pointed.
There may be more than one unconnected effective boresight area to which a single steerable satellite beam is intended to be pointed.

Effective Antenna Gain Contour (of a steerable satellite beam): An envelope of antenna gain contours resulting from moving the boresight of a steerable satellite beam along the limites of the

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Last modified: February 24, 1997

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Committee on Radio Astronomy Frequencies [http://www.nfra.nl/craf/s5_149.htm

The Committee on Radio Astronomy Frequencies (CRAF) is a committee of the European Science Foundation (ESF).

ITU-R Footnote S5.149:
In making assignments to stations of other services to which the bands:

13.36 - 13.41 MHz, 6650 - 6675.2 MHz* 140.69 - 140.98 GHz*25.55 - 25.67 MHz 10.6 - 10.68 MHz, 144.68 - 144.98 GHz* 37.5 - 38.25 MHz,14.47 - 14.5 GHz* 145.45 - 145.75 GHz*73 - 74.6 MHz (in Regions 1 and 3)22.01 - 22.21 GHz*146.82 - 147.12 GHz*150.05 - 153 MHz (in Region 1)22.21 - 22.5 GHz150 - 151 GHz*322 - 328.6 MHz*22.81 - 22.86 GHz174.42 - 175.02 GHz*406.1 - 410 MHz23.07 - 23.12 GHz*177 - 177.4 GHz*608 - 614 MHz (in Regions 1 and 3)31.2 - 31.3 GHz178.2 - 178.6 GHz*1330 - 1400 MHz*31.5 - 31.8 GHz (in Regions 1 and 3)181 - 181.46 GHz*1610.6 - 1613.8 MHz*36.43 - 36.5 GHz*186.2 - 186.6 GHz*1660 - 1670 MHz42.5 - 43.5 GHz*250 - 251 GHz*1718.8 - 1722.2 MHz*42.77 - 42.87 GHz257.5 - 258 GHz*2655 - 2690 MHz43.07 - 43.17 GHz*261 - 265 GHz3260 - 3267 MHz*43.37 - 43.47 GHz*262.24 - 262.76 GHz*3332 - 3339 MHz*48.94 - 49.04 GHz*265 - 275 GHz3345.8 - 3352.5 MHz*72.77 -

72.91 GHz*265.64 - 266.16 GHz*4825 - 4835 MHz*93.07 - 93.27 GHz*267.34 - 27.86 GHz*4950 - 4990 MHz97.88 - 98.08 GHz*271.74 - 272.26 GHz*4990 - 5000 MHz
are allocated (* indicates radio astronomy use for spectral line observations), administrations are urged to take all practicable steps to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service
-- Last modified: December 1, 1997

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NANÇAY Decametric Array - Technical presentation [http://www.obs-nancay.fr/html_an/a_tecdam.htm

<Picture>

• Characteristics of the antennas in the array • Receivers • Observations and measurements

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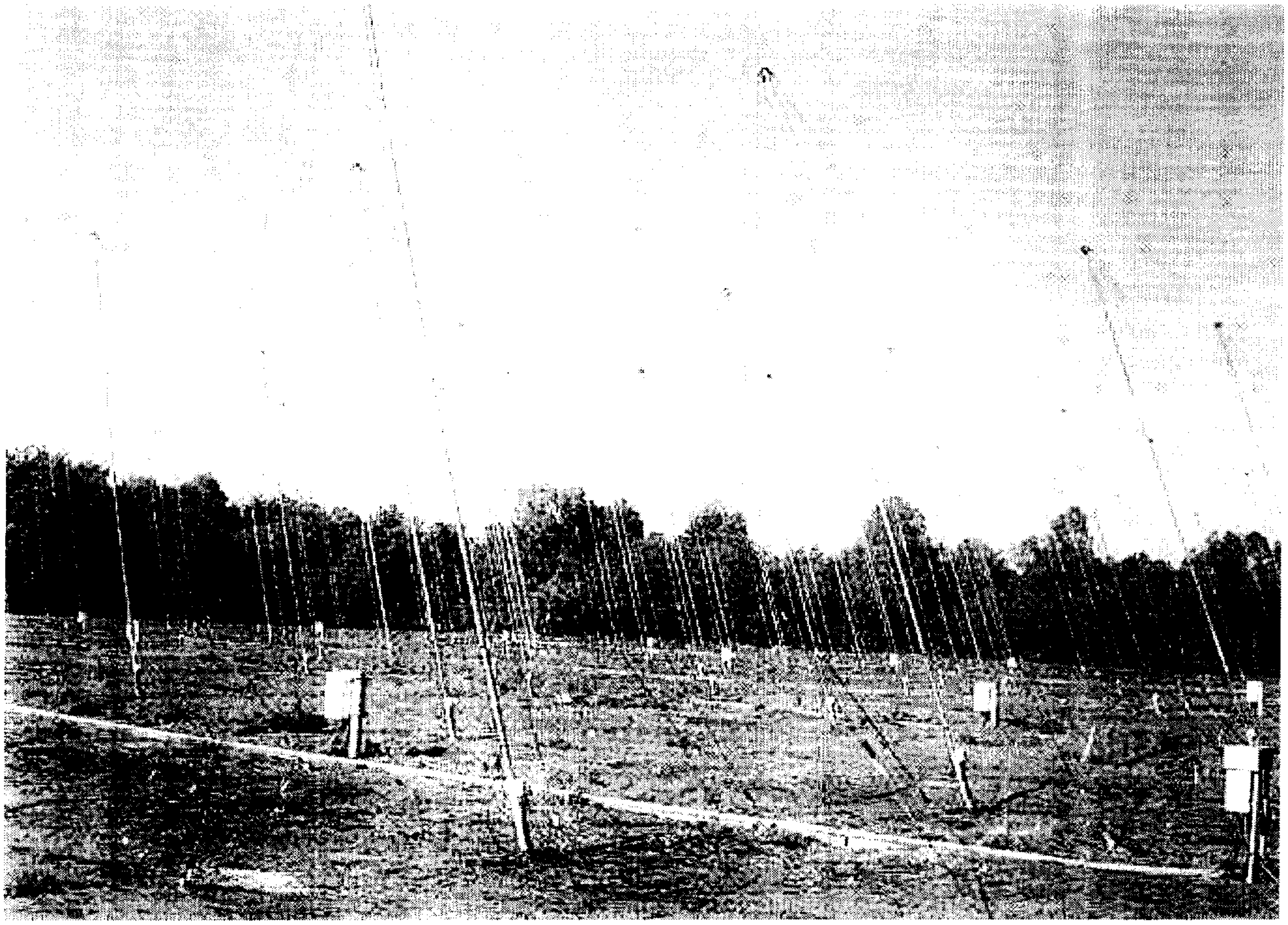
Characteristics of the antennas in the array

The Decametric Array is an interferometer consisting of 144 antennas: the 8 conducting wires on each antenna have been wound in a spiral pattern on a conical surface - giving them the nickname of Teepee antennas, after the amerindian conical tents. The wires on the antennas are wound in either a left- or a right-handed winding spiral pattern, making them sensitive to either left- or right-hand circularly polarized radio waves. Thus, the Decametric Array exists in fact of two sub-arrays of 72 antennas each, and is capable of measuring circular polarisation, which is very important since the radiation from Jupiter is highly polarized. The frequency range that can be observed is 10-100 Mhz (or 3-30 meter wavelength): beyond 100 MHz lies the metric wavelength domain, and below 5 to 10 MHz the radiation from celestial objects is reflected back into space by the Earth's ionosphere, the uppermost layer of the atmosphere ionized by ultraviolet radiation from the Sun.
Each of the two arrays has a total collecting area of about 3500 square meter, the equivalent of a round dish of 67 meter diameter. This large area allows the detection in 1 second of a 1000 Jansky source in a 50 kHz bandwith (the Jansky is the astronomical flux density 9"source brightness") unit, and equivalent to 10^-26 W m^-2 Hz^-1). The corresponding gain is 25 dB at a frequency of 25 MHz, or 300 times (?) that of an omnidirectional antenna. The principal beam, i.e. the spatial resolution, has a size of 7 by 14 degrees (!) - large compared to the actual size of a few degrees for the solar corona or only a fraction of a degree for Jupiter's magnetosphere, as seen from the Earth. This "nearsightedness" remains the weak point of observations at such long wavelengths (except for very-long baseline interferometry, VLBI). It does not permit detailed imaging and prevents therefore the localization of the radio emission in or near the observed radio source. Fortunately, this lack of spatial resolution is compensated by the high frequency and time resolution of the observations made with the Decametric Array.



The receivers
Since 1988-90 the observations are essentially digital, and made with three powerful and complementary receivers:

•A frequency-sweeping spectral analyzer (ASB):
Provides us with systematical broad-band observations of Jupiter and the Sun, with a time resolution of about 1 second, during about 6 to 8 hours per day, around the meridian passage of each object. It records both left- and right-hand polarized radiation. It also serves in the preparation of specialized observations (like those of Saturn or stars). The observed data (1 to 3 Mbyte per hour) are stored on CD-ROMs and made available to the scientific community. •A frequency-sweeping polarimeter:
Allows the full-polarisation analysis of the detected radiation, in all 4 Stokes parameters. It is the only existing receiver of its kind, and is mainly used to study the radio emission of Jupiter. The entire frequency band analyzed is covered in 1.25 seconds, and 2 to 3 Mbyte of data is recorded per hour. •An acousto-optical spectrograph:
As its name indicates, it converts radioelectric signals into acoustic vibrations, which interact inside a cristal with a laser beam to produce the spectrum of the radio signal. It provides both a very high time resolution (up to 300 spectra per second!) and a good spectral resolution (13-50 kHz), though in a single polarization only.
A high sensitivity can be reached with it (about 50 Jansky) after integration in frequency, since it observes the entire frequency range simultaneously. Its high data production rate (400 kbytes per second) require a high speed digitalization and acquisition rate.

Observations and Measurements
The data acquisition is made with a PC, and the data are then transferred over the local network to a Vax workstation, where the first display and data analysis is made with programs developped in an IDL environment.
All data are represented as so-called dynamical spectra: intensity (or energy) as function of time and frequency (in false colors, where colors represent intensity levels). These images show the wealth of information represented by the

Decametric Array observations, the instantaneous spectra and their time evolution. They can be treated with algorithms similar to those which can be applied to optical images in order to extract the information.
This represntation, possible due to the large bandwidth of the observations, also allows the a posteriori analysis (and sometimes the elimination) of man-made interference. It partly compensates the lack of spatial resolution at these very long wavelengths, since different frequencies originate from different parts of the radio source (whether the Sun or Jupiter). A dynamical spectrum thus represents an "onion ring" cut through different layers of the radio source. The constant maintenance of the array, the reliability and improvement of the receivers permits us to keep the Decametric Array working at a high performance level. The only degradation of the observations is due to the ever increasing number and intensity of man-made radio interference signals.

Last Modified November 27, 1997 **Webmaster@obs-nancay.fr**

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NANÇAY Decametric Array - History and Presentation [http://www.obs-nancay.fr/html_an/a_predam.htm
<Picture>
The Decametric Array of Nançay (RDN) is dedicated to the study of the magnetic and ionized environment of planets (mainly Jupiter), the Sun and stars. In these plasmas not only the low-frequency emission (decametric radio waves) detected with the Decametric Array are produced, but also very low frequency emission (at kilometric wavelengths) and ultraviolet radiation (planetary aurorae).
The radio observations show a variety of phenomena (down to time scales of less then a second: the so-called millisecond bursts of Jupiter, and solar and stellar eruptions) which allow the study of the dynamics of these ionized plasma environments.
This instrument, developped in the years 1975-1978 under the direction of Andre Boischot, operates at wavelengths between 3 and 30 meter, and consists of 144 helical antennas of 9 meter high and 5 meter in diameter at their base, distributed over an area of 10,000 square meter. The broad-band spectroscopy of the emissions, often very variable, requires specialized, very fast receivers which can take several thousand measurements per second, which were developped for the Decametric Array using state-of-the-art technology, like that of acousto-optical spectrometers. For even longer wavelengths,which can not be observed from the ground, measurements have to be done by spacecrafts, such as Voyager, Ulysses or Galileo, in association with the telescope at Nancay.

Users of the Decametric Array are researchers from the Paris Observatory (ARPEGES radio astronomy department), in collaboration with French and foreign Institutes, such as: the Space Research Department (DESPA) of the Paris Observatory, the Center for Terrestrial and Planetary Environment Studies (CETP, Velizy, France), the Space Astrophysics Institute (IAS, Orsay, France), the Max-Planck Institute for Aeronomie (Lindau, Germany), the Space Research Institute in Graz (Austria), and the Radio Astronomy Institute in Kharkov (Ukraine).

The main research goals are:
•(1) Understanding the mechanisms leading to the production of radio waves with a very high efficiency (the equivalent temperature of heat-radiating bodies that produce radio emission as intense as that of Jupiter or the Sun is 10^15 K - a million billion degrees !). •(2) The remote measurement of the physical state of the plasma in the emitting sources (density and energy of the electrons, mapping of the magnetic field), which cannot be obtained by other means, using the results of (1).

The research done with the Decametric Array results in about 5 to 10 scientific publications per year.

Last Modified November 27, 1997 **[Webmaster@obs-nancay.fr**

ERC REPORT

European Radiocommunications Committee (ERC) within the
European Conference of Postal and Telecommunications Administrations (CEPT)

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COMPATIBILITY BETWEEN RADIO FREQUENCY IDENTIFICATION DEVICES (RFID) AND THE RADIOASTRONOMY SERVICE AT 13 MHZ

[Menton, May 1999]

COMPATIBILITY BETWEEN RADIO FREQUENCY IDENTIFICATION DEVICES (RFID) AND THE RADIOASTRONOMY SERVICE AT 13 MHz

Introduction

The band 13.553-13.567 MHz is designated by the ERC recommendation ERC/REC 70-03 for non specific Short Range Device (Annex 1) and Inductive Applications (Annex 9). The fieldstrength level is 42 dBµA/m at 10 m, equivalent to approx. 10 mW ERP.

Industry has developed RFID for a number of new applications such as ticketing systems, access control, logistics applications, car entry, container identification, contactless credit card, ect. RFID systems at 13.56 MHz use a modulated signal according to Annex 1 or 9, with a fieldstrength level of 42 dBµA/m at 10 m. A modulated carrier must meet the transmitter mask of Annex 9 (Inductive Applications) at 13.41 MHz or lower frequencies, the modulation products must meet the spurious level of -3.5 dBuA/m (as per the draft EN 300 330).

The band 13.36-13.41 MHz is allocated to the radio astronomy service on a primary basis. In Europe, the only radio astronomy site operating at 13 MHz is Nancay (France).

Thus, the purpose of these measurements was to evaluate the interference potential of out of band and spurious emissions of 13.56 MHz RFID systems into the radio astronomy band.

Description of Nancay activities at 13 MHz

The Decametric Array is an interferometer consisting of an array of 144 phased antennas. It is composed of two sub-arrays of 72 antennas, placed over an area of 10,000 square metres. The array is capable of measuring circular polarisation, which is very important since the radiation from Jupiter is highly polarised.

The frequency range that can be observed is 10-100 MHz (or 3-30 metre wavelength): a typical observation for Jupiter activities ranges from 10 MHz to 40 MHz and from 20 MHz to 75 MHz for solar emissions. These frequencies are scanned every 350 msec.

The sensitivity of the receiver is equivalent to 10^{-24} W/m2/Hz, the antenna gain is 25 dB at a frequency of 25 MHz. The principal beam, i.e. the spatial resolution, has a size of 7 by 14 degrees (large compared to the actual size of a few degrees for the solar corona or only a fraction of a degree for Jupiter's magnetosphere, as seen from the Earth). The resolution bandwidth is 3 kHz.

Around the site of Nancay, two protection zones are defined:

- Within a radius of 1 km, the installation of any radio transmitter is forbidden
- Within a 3 km radius, the radioastronomy site must be consulted when installing new radio transmitting equipment

Description of the RFID systems

An RFID system consist of an interrogator or a reader and one or several tags as data carriers. The tags are attached to objects like warehouse goods or carried by human beings as smart cards or ticketing cards. RFID systems are used in logistics for manufacturing or in automotive applications, e.g. immobilisers or radio keys (Car entry) systems, and in transportation for baggage tagging. Tags are only active when interrogated by the reader. They are normally batteryless, dormant and powered by the RF interrogation signal to respond with a data signal. The power level of tags is typically 60-80 dB below the carrier level of the interrogator.

Most RFID Systems use bidirectional communications which means that the interrogation signal which is needed to power the tag, is modulated by ASK (Amplitude Modulation). To minimize the emitted spectrum with regard to amplitude and frequency, a low level ASK modulation (10%) in combination with optimized data transmission (encoding) methods are used.

RFID Systems under test in Nancay were supplied by Philips and Texas Instruments (TIRIS) (see FIG.1). The actual emission levels of the equiment has been verified by a Rohde Schwarz measurement receiver. The carrier power levels were adjusted to meet the below indicated emissions as defined by the ETSI Standard EN 300 330 (Final draft) and the ERC/REC 70-03, Annex 1 and 9.

System 1

The first RFID system used for the test was prepared by Philips and consisted mainly of the following parts:

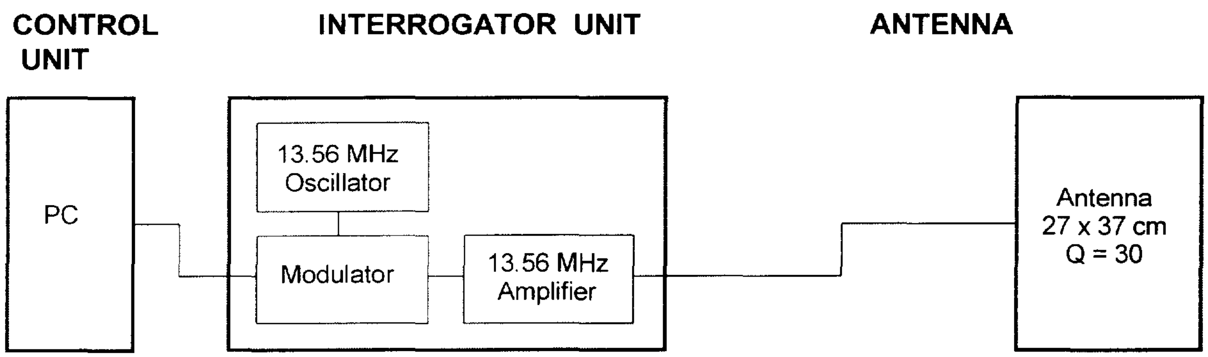

FIG. 1

It was considered as reference system since it allowed all adjustments needed for the test variants.

The used coding was a "1 out of 256" Pulse Position Code:

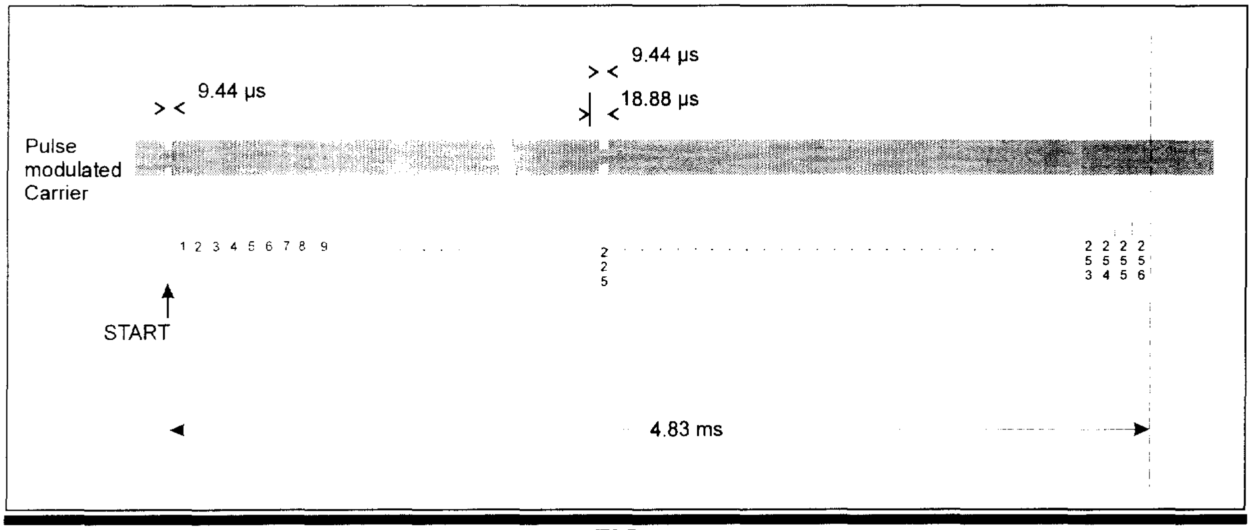

FIG. 2

At the beginning of each transmission a start bit is sent. The position of a single pulse within a 256 position frame contains 1 Byte information. Therefore only one modulation is necessary to transmit one byte (see FIG.2).

<u>Transmission Frame:</u>
One transmission frame consists of 1 start bit (1 modulation) and 8 bytes data coded as shown above (total: 9 modulations). The data bytes are determined randomly for every transmission frame. This transmission frame is sent with a defined repetition rate.

System 2

The second system was prepared by Texas Instruments and used in the tests and for verification of a parasitic 13.038 MHz signal observed during one of the tests. The antenna size was 10x16 cm.

All RFID emission levels were adjusted for each measurement to stay within the limits of the below given maximum carrier or spurious levels.

Three different modes were used

A. an unmodulated carrier with a field strength of 42 dBµA/m at 10 m

B. a 10 % modulated carrier with a repetition rate of 80 msec, so that the maximum radiated field strength in the radio astronomy band is – 13.5 dBµA/m at 10 m, which is below the spurious emission level

C. a 100% modulated carrier with a repetition rate of 250 msec, so that the maximum radiated field strength in the radio astronomy band is – 3.5 dBµA/m at 10 m, which corresponds to the spurious emission level

A second system (Texas Instruments) transmitted only an unmodulated carrier with a measured field strength of 42 dBµA/m at 10 m (system D).

Measurement configurations

For each measurement, the RFID emission was directed towards the antennas of the decametric array. The RFID system was turned "on" during 5 minutes, than "off" during the same period in order to record the environmental noise for comparison. This procedure was needed to allow the integration of the data over 5 minutes and allow direct comparison between the RFID system (on time) and the environmental noise (off time) recordings.

The measurements were performed at three different locations as described in the next paragraph, all times are in UTC:

Location 1 In the antenna field, at approximately 10 m of the decametric array: modulations schemes A, B and C were tested between 9h52 and 9h57, 10h12 and 10h17 and 10h55 and 11h00 (see Annex I-IV),.

Location 2 In a car park at about 1.5 km far from the decametric array: systems A, C and D were tested between 12h17 and 12h22, 12h29 and 12h34 and 12h44 and 12h49 respectively.

Location 3 In front of the church in Nancay, at about 3.5 km from the decametric array: systems A and C were tested between 13h02 and 13h07, and 13h14 and 13h19 respectively

(For all measurements the spectrum was also recorded when the RFID systems were switched off, see Annex 4 and 5)

The Table 1 below summarises the different configurations identified by timing and location.

	(1) Philips System			**(2) TIRIS System**
Measurement site	A: unmodulated	B: 10% modulation	C: 100% modulation	D: unmodulated
(1) Astronomy Antenna	9h52 - 9h57	10h12 - 10h17	10h55 - 11h00	
(2) Parking (1.5 km)	12h17 - 12h22		12h29 - 12h34	12h44 - 12h49
(3) Church (3.5 km)	13h02 - 13h07		13h14 and 13h19	

Table 1

Results

For the purpose of the tests, the astronomy receiver was configured as follows:

Fmin :	13 MHz
Fmax :	14 MHz
Resolution :	3 kHz
Scantime :	350 msec
Ref level	-40 dBm

(1) Interferer adjacent to the Antenna field

The position of the RFID system relative to the Astronomy antenna field was about 10-12 metres from the edge of the antenna field and the inductive antenna positioned such that the main lobe of the RFID antenna radiated towards the antenna field.

The results of the measurement for the systems 1(C) (100% modulated), the worst case, is given in Annex 1 to 3.

Annex 1 shows the measured power of – 55 dBm at the input of the radio astronomy receiver in the SRD band for the frequency 13.56 MHz. This frequency is outside the radio astronomy band. When the system 1 (C) is turned off at 11h00 (UTC), the signal disappears.

The received signal is 40 dB above the "sky" level (i.e. the level measured when the SRD system is off).

Annex 2 shows the same measurement at 13.038 MHz. The received signal is also outside the radio astronomy band, and is measured at –83 dBm.

The manufacturers declared that the signal at 13.038 MHz is a parasitic (spurious) signal of the particular system under test, caused by the modification for controlling the modulator by the PC. This signal will not be emitted by systems to be put on the market. In fact, a control measurement using the second RFID system did not exibit this signal so this frequency is not inherent to RFID systems nor is this frequency a result of intermodulation of the astronomy receiver.

Annex 3 shows also a time domain recording but inside the astronomy band (13.398 MHz). The level of the received interference signal was –95 dBm at the receiver input level. This corresponds to the highest side lobe of the modulated RFID signal.

Annex 4 shows the result of the integrated data over the 5 minutes "on" and "off" respectively. The two lines at 13.56 MHz and 13.038 MHz are visible. The graph also shows the third line, which falls within the radioastronomy band at 13.398 MHz. The power is about –95 dBm at the astronomy receiver input and is 20 dB above the environmental noise and clearly visible by the radiotelescope.

(2) Interferer positioned in the car park (1.5 km)

The position of the RFID system was about 1.5 km from the center of the antenna field but still inside the Nancay observatory site. The main lobe of the H-field emission was also directed towards the antenna field.

Annex 4 gives the measured signal integrated over the 5 minutes "on" and "off" respectively, for the system A.

Both graphs show that no signal could be detected during the "on" period.

Even the 13.56 MHz carrier of the RFID system was not detectable.

At a distance of 1.5 km, the radiotelescope is not disturbed by the SRD.

environment (e.g. wood), the fact that the main lobe of the decametric antenna points towards the sky, implying attenuation for sources on the surface. These factors add up and provide protection to the radiotelescope against potential interference of the SRD RFID.

(3) Interferer positioned in front of the church (3.5 km)

The location of the RFID systems was in the centre of Nancay and in front of the church, the distance was about 3.5 km –air- to the antenna field. This position is still within a controlled zone where radio systems must be co-ordinated with the radio astronomy site on a consultation basis.

The results are similar to those obtained in (2): no signals from the RFID systems could be recorded.

Conclusions

The only case of interference which was recorded in the radioastronomy band occurs when the SRD is very close to the decametric array (few metres), which is a very unrealistic case.

In this case the interference signal is approx. 20 dB above the observed environmental noise at the radioastronomy receiver input.

As soon as the distance increases to 1.5 km, just outside first the protection area, no signal is detected in the radioastronomy band nor from the 13.56 MHz powering carrier frequency at a level of 42 dBuA/m @ d=10m..

The spurious level of –3.5 dBμA/m at 10 m in the astronomy band 13.36-13.41 MHz is sufficient for inductive 13.56 MHz RFID systems to protect the radioastronomy site of Nancay; so a margin of 45.5 dB is realised (See Note 1 below).

The results and conclusions are representative for decametric astronomy receiving sites.

Annex 1: Measurement in the Antenna field, 13.56MHz signal

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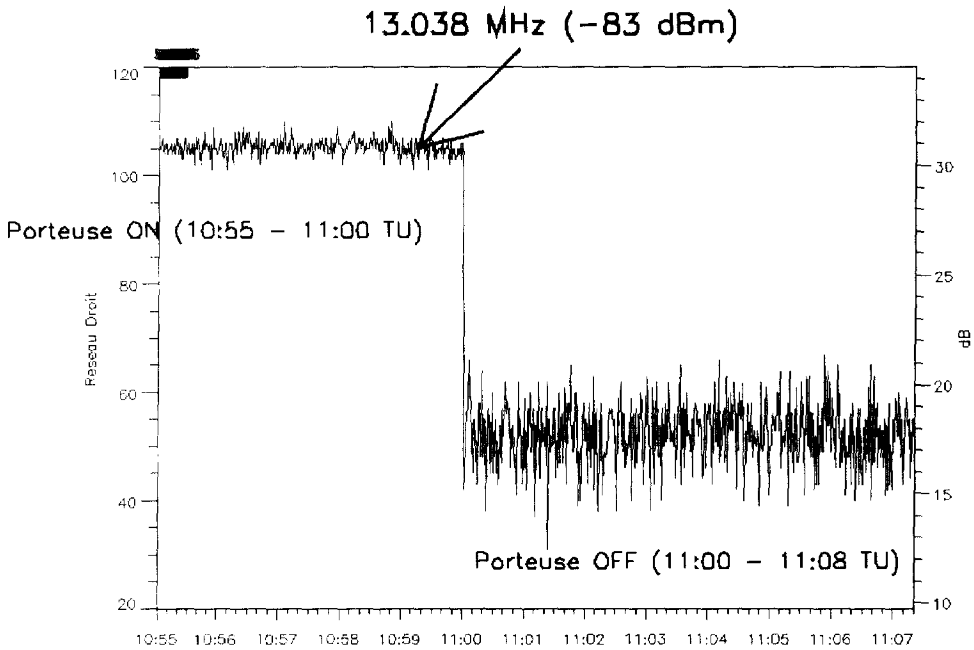
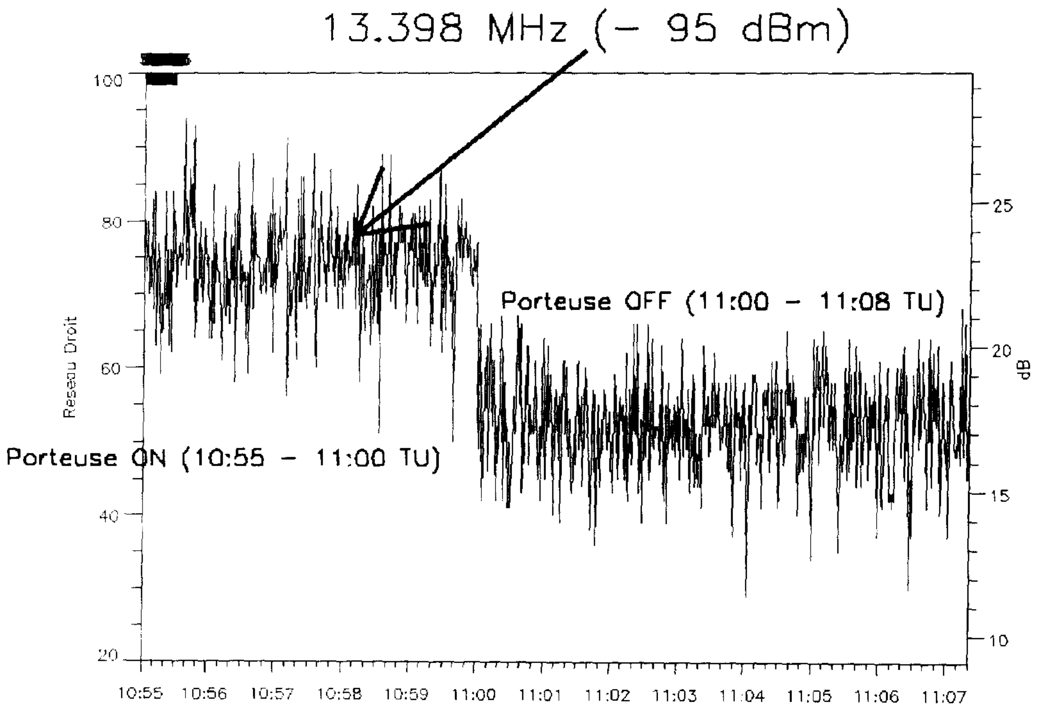
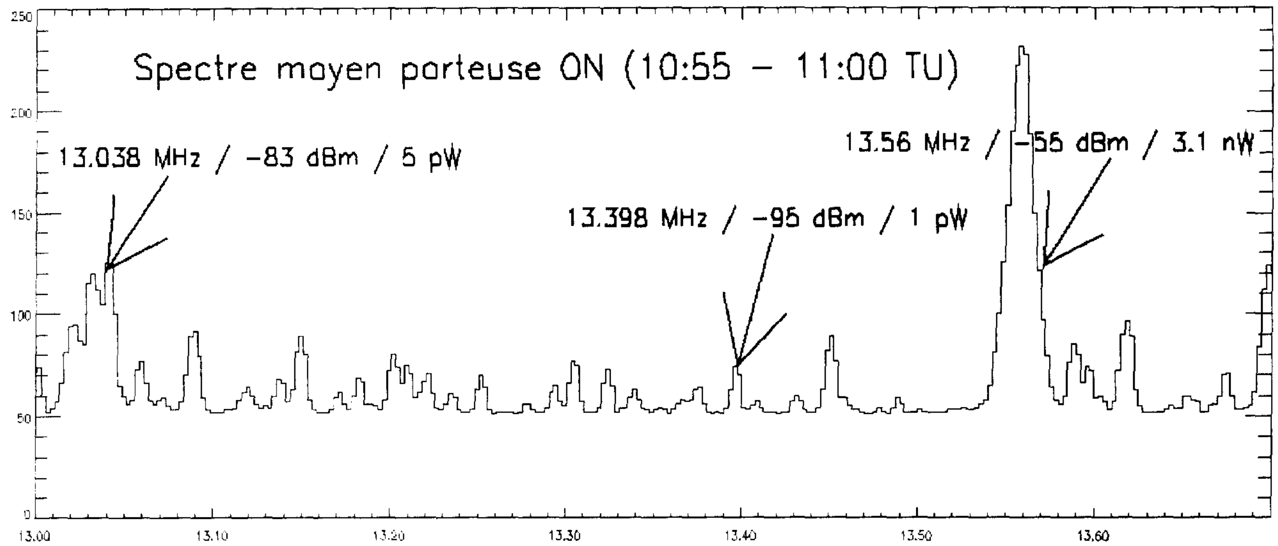
Annex 2: Measurement in the Antenna Field, 13.038 MHz signal
Spurious signal

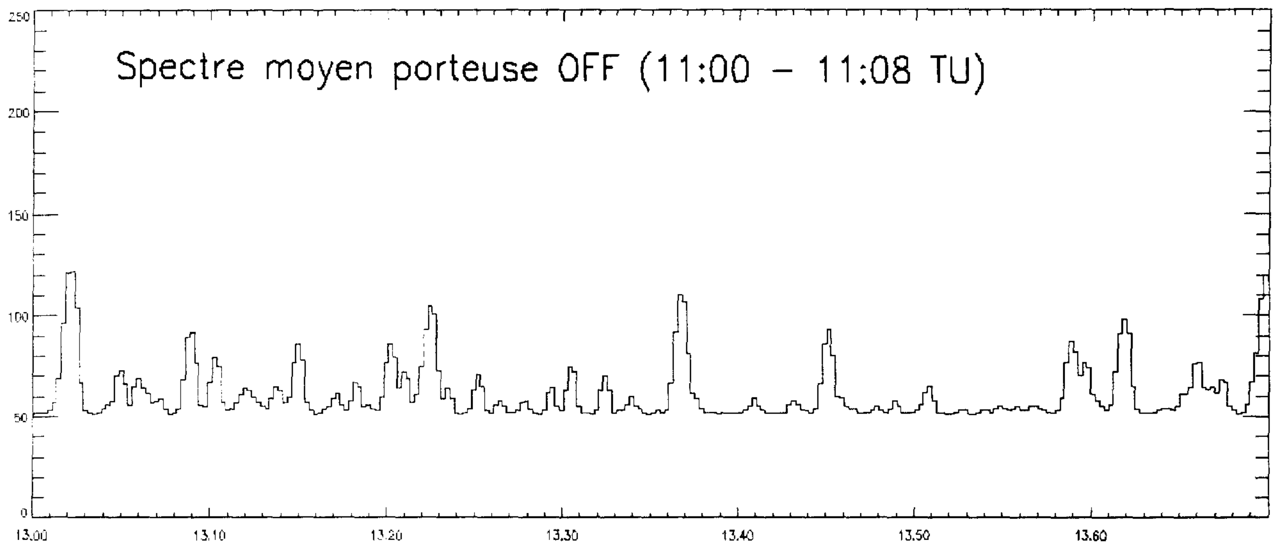


Annex 3: Measurement in the Antenna Field, 13.398 MHz signal A modulation product

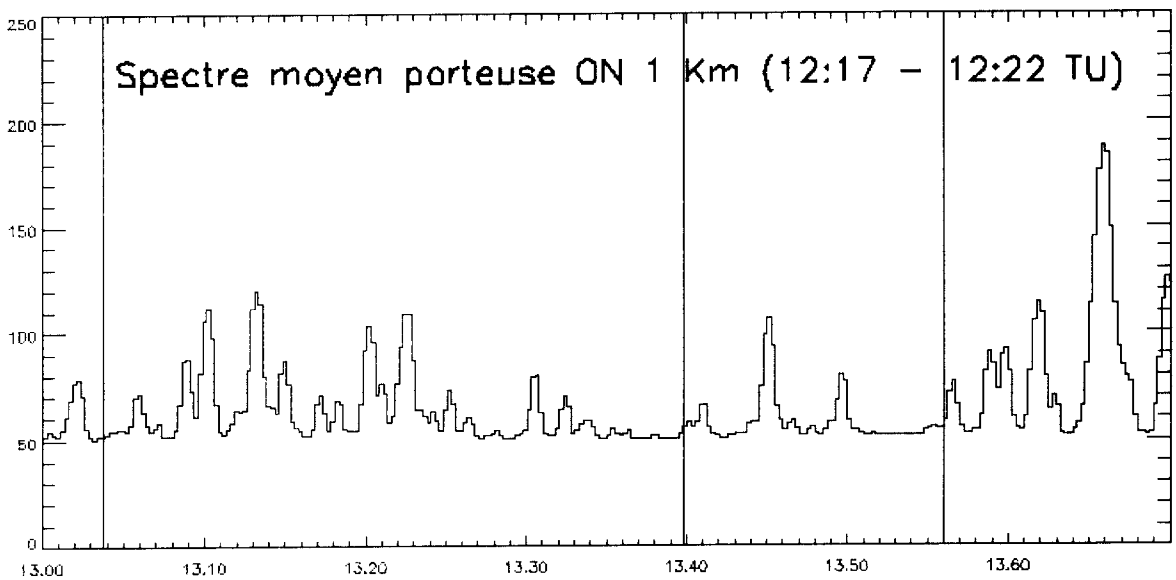


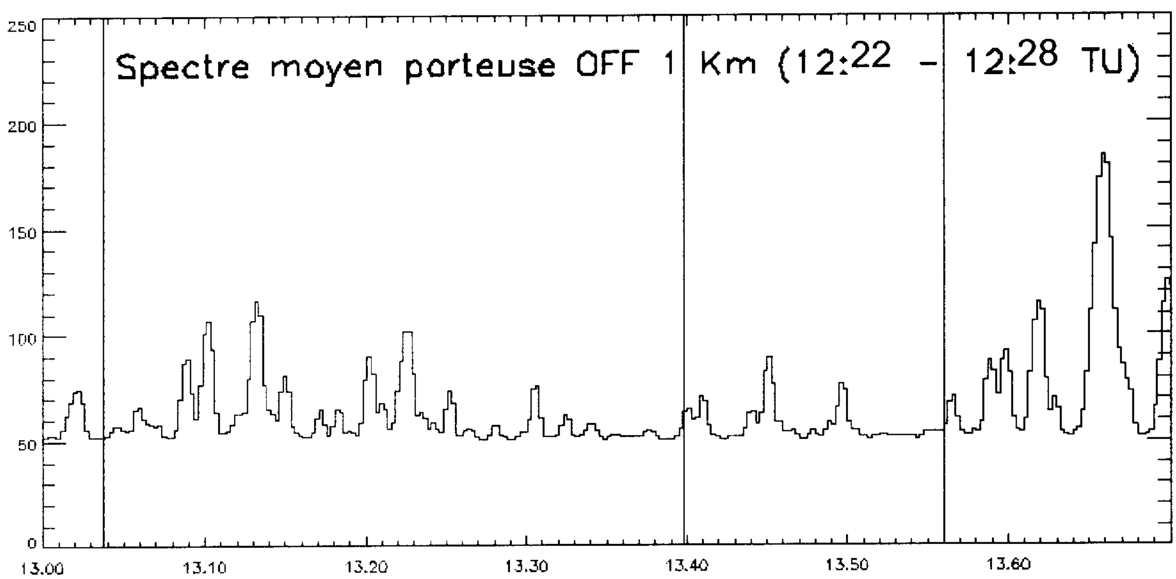
Annex 4: Measurement in the Antenna Field, Frequency spectrum, RFID transmitter "on"
Measurement in the Antenna Field, Frequency spectrum RFID transmitter "off"





Annex 5: Measurement in Car Park, 1.5 km from the Antenna.
RFID transmitter "on“
Measurement in Car Park, 1.5 km from the Antenna.
RFID transmitter "on“





Annex 6: Photograph of the antenna array site